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Compts

ON THE

PATHOLOGICAL CONDITION

OF THE

BLOOD IN CHOLERA.

BY

ALFRED BARING GARROD, M.D.

ASSISTANT PHYSICIAN TO UNIVERSITY COLLEGE HOSPITAL.

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ON THE PATHOLOGICAL CONDITION OF THE BLOOD IN CHOLERA.

By ALFRED BARING GARROD, M.D., Assistant Physician to University College Hospital.

(From the London Journal of Medicine.)

The author of the following paper feels some hesitation in publishing the analyses, which he has had the opportunity of making, as to the condition of the Blood in Cholera, but has been induced to do so for the following reason: that at the present time it is exceedingly doubtful whether the disease is likely to disappear altogether from this country, or whether the cases, which have already occurred in London, are only the forerunners of a much more severe visitation. If the former should fortunately be the case, the results of the investigations, unless quickly published, would soon lose their interest; if the latter, their being made known may elicit further inquiry into the subject, and hence be a means of causing the important changes, which the blood undergoes in this affection, to be much more satisfactorily determined. His hesitation arises from the analyses having been by no means so numerous or satisfactory as he could wish, on account of the great difficulties which have been experienced in London, during the present epidemic, in procuring blood from Cholera patients when alive. Hence, he has been compelled to make use of that obtained at post-mortem examinations—a proceeding by no means so satisfactory, on account of the probability of partial coagulation having taken place in the vessels, and therefore of the blood not being obtained in its entire state; that is to say, in some cases an undue proportion of the serum, in others, of the cruor, being procured. Frequently also, it is impossible, in such blood, to separate a quantity of serum sufficient for analysis; and therefore, in many cases, the most important portion of the blood cannot be properly examined. As many valuable investigations of the blood in Cholera were made during the last epidemic (1831-32), it may not be uninteresting to the reader, at the present time, to be enabled shortly to survey the results then obtained, and find in what points they agree, and in what they differ, from those recently observed.

With all the attendant difficulties, however, I think we shall be able to demonstrate, that our knowledge of the pathological changes of the blood in Cholera is as perfect as in any other disease, and that, which certainly must be considered as an important fact, we shall be able to solve the following problem. Given, *a specimen of human blood*:— determine *whether it was derived from a Cholera patient.* If we can effect this, it certainly must be allowed, that our knowledge of the blood in Cholera, although confessedly imperfect, far surpasses that in most other affections.

In reviewing the facts which have been well made out, concerning the morbid conditions of the human blood, we shall find, that although much which is exceedingly important has been established, yet that very much still remains to be effected; and that the diseases, in which a pathognomonic condition has been discovered, are very few in number. Among these, we may enumerate inflammatory affections, characterized by the constant increase of the amount of the fibrine; anæmic conditions of the system, by the diminution of the amount of the blood corpuscles; certain affections of the kidneys, by the great diminution of the albumen of the serum, and, at the same time, an accumulation of urea in the blood; gout, by the existence of uric acid in the blood; diabetes, by the presence of sugar; and icterus, by the colouring principle of the bile being found in the circulating fluid. These are the most important facts that we possess on the subject, and, it will be observed, that some, even of these changes, only indicate general conditions of the system, and will not enable us to form an opinion as to the individual organ affected; thus we find, as far as our analyses will enable us to judge, the same state of blood in pneumonia, pleuritis, peritonitis, acute rheumatism, etc., although no doubt many important differences really exist; at present, we only have the power of ascertaining that inflammation is going on somewhere in the system, and of judging of the structures affected, or of the intensity of that inflammation, by the amount of increase which the fibrine has experienced. Again, from an examination of the blood, we cannot determine from whence an anæmic condition of that fluid proceeds, whether it arises from loss of blood, from bad nutrition, chlorosis, the poison of lead, etc. Taking, then, into consideration how extremely imperfect is the knowledge we possess of the pathology of blood in general, I think we must allow, that should we be able to define a condition of this fluid which is pathognomonic of Cholera, a very important step has been attained.

We shall divide our subject into two parts. The first will contain a short account of the results which were obtained during the former epidemic of Cholera in Europe; the second will treat of the analyses recently performed.

I. CHEMICAL EXAMINATION OF THE BLOOD IN CHOLERA, PREVIOUS TO THE PRESENT EPIDEMIC.

During the years 1831 and 1832, the most active and successful investigators of the chemical pathology of Cholera were, Dr. O'Shaughnessy, Dr. Thomson, and Dr. Clanny, in this country; and on the Continent, MM. Lecanu, Hermann, Rose, and Wittstock. As far as physical characters are concerned, it had been often observed that, in Cholera

patients, the blood drawn during life, and, also that found in the large vessels after death, exhibited a condition differing from that seen in a state of health, or after death, from most other causes. On this point Dr. Ainsley observes, that he always found the large veins, both of the general and portal system, the sinuses of the brain, and the right cavities of the heart, loaded with a *thick, viscid, and black blood;* and when blood was found in the left cavities of the heart, it had a similar appearance. The lungs, and all the internal viscera, presented a greater or less degree of congestion from *pitchy* or *black blood*. Dr. Ainsley also states, that the blood exhibited morbid appearances, even when drawn from the patient at an early period of the disease; and as this advanced to a fatal issue, the characters above described were most manifest. He also considers this state of blood as one of the earliest links in the chain of effects, consequent on the invasion of the efficient causes of the disease, and a strong diagnostic mark. A similar appearance of the blood has been remarked by many others. Lecanu analysed the blood of four patients suffering from Cholera, with a view of discovering the amount of solid matter and water contained in it, and he found—

	1st Case.	2nd Case.	3rd Case.	4th Case.
Water	660	749	480	670
Solids	340	251	520	330
	1000	1000	1000	1000

Now the mean of ten analyses, made by the same observer, of healthy venous blood, taken from individuals from twenty-six to sixty-two years of age, gave in round numbers—

Water	789
Solids	211
	1000

It thus appears, that the watery portion of the blood is very deficient, the solids in one case being nearly double the amount found in health. The fibrine was deficient in quantity, and the blood corpuscles were increased in number.

Wittstock found, in a case of Cholera, that the blood was healthy in appearance, the clot of a scarlet red colour on the surface, but darker than usual in the interior. The serum had a specific gravity of 1038·5, and in 1000 parts contained 137·5 of solid matters.

1000 parts of blood gave—

Water	740·00
Solids	260·00
Blood corpuscles	124·46
Fibrine	11·00
Albumen	110·42
Extractives and Salts	14·10

The fibrine in this analysis was undoubtedly estimated far too high, for 11 parts of this proximate principle cannot exist in the 1000 parts of blood without causing a decidedly abnormal appearance, which, as stated above, was not observed; and many other instances are on record, as in Dr. Clanny's analyses, where the fibrine was only washed and pressed, but not thoroughly dried, and, consequently, the figure in the

table increased four or five fold. It will be seen that the specific gravity of the serum is greatly above the normal average, (which may be taken as 1028, water being 1000); and I may mention here, that an increase of 10 parts in the 1000 in the specific gravity of the serum is an alteration of the gravest importance, for this portion of the blood remains remarkably fixed in the proportion of its normal constituents, and a notable increase or decrease is not induced, except by the presence of deep-seated and dangerous disease. The total amount of solids in the blood is seen in this case to be much larger than in health, which, as mentioned above, were found by Lecanu to be about 211 parts in the 1000; this was due, in a great measure, to the large proportion of albumen, for 110 parts were contained in the 1000 of blood, in place of 69 parts, the mean amount in health. The red corpuscles appear to have been in about the usual quantity; the extractives and salts were estimated together, and with them the fatty matters were probably included, so that little can be made out concerning them.

M. Hermann, of Moscow, made an analysis of the blood, taken a few hours before death, from a man suffering from Cholera, and found it of a very viscid consistence, and dark in colour. The proportion of crassamentum to serum was as 60 to 40; whereas in health, the relation is about 43 to 57; thus indicating a considerable deficiency in the watery portion of the blood. The serum was alkaline, of specific gravity 1036. The crassamentum is stated to have been acid in reaction.

In the *Gazette Médicale de Paris* (Jan. 14, 1832) are contained the results of the analyses of Cholera blood, made by MM. Rose and Wittstock of Berlin, which are thus stated:

"MM. Rose and Wittstock have communicated to us the results of their experiments on the blood of persons labouring under Cholera. Despite of all the exactitude of their researches, they could not find the acid character of the blood, which M. Hermann asserted to exist. They have observed, that when the blood contained in the right ventricle of the heart of the Cholera patient is dried with great care, 30 parts per cent. of solid matter are invariably obtained; while, in the state of health, the blood only affords 21 per cent. This morbid proportion has been constantly found, as well in the blood of children as of old persons; neither did sex occasion any difference in the results. The serum of the blood of a young man, ætat. 20, who died of intense Cholera, was of specific gravity 1047, and afforded, when dried, 16 parts per cent. of solid matter. In a young woman, in good health, MM. Rose and Wittstock found the specific gravity 1028, and the serum only contained 9½ per cent. of solid matter. The dejections were strongly alkaline, and contained albumen. These experiments, frequently repeated at the Cholera Hospitals of Berlin, have invariably been attended with the same results."

We have now to speak of the researches of Dr. O'Shaughnessy, which are far more extensive and elaborate than those already detailed; he adopted the method then recently proposed by Lecanu, and used his analysis of healthy blood and serum as standards of comparison. His results are contained in a *Report on the Chemical Pathology of Malignant Cholera*, 1832. The analyses there published contain also some account of the patients from whom the blood was derived; and I will make

extracts from the pamphlet, as it is very important to know the condition of the patient at the time the blood is obtained.[1]

"Case I. *Malignant Cholera.* Mrs. Barras, æt. 39, widow, of excellent habits, good general health, in rather comfortable circumstances, and residing in a lane adjoining the river, Sandgate, Newcastle, was seized with cramps, epigastric pain, and giddiness, at about 10 p. m., on the night of the 17th December. According to the statement of her female friends, she soon after became deadly cold, her countenance altered to the expression of death, she lost all voluntary power, and her eyes became deeply sunk in their orbits. In this state she is reported to have spent the night, having vomited and been purged about six times. A more precise history could not be obtained.

"At 9 a. m. on the 18th, she was seen by Mr. Nesham, by whose direction a vein was opened in the arm. The blood issued difficultly, was at first viscid and very dark, but it subsequently assumed a more lively colour. The blood was placed aside, in a small basin, and at 11 a. m. (when I arrived) had separated into a loose, bulky crassamentum, and transparent, but unusually viscid, serum. The crassamentum having been disturbed and broken up by some of the gentlemen present, the serum only was removed for analysis. The patient passed no urine from the commencement of the attack, until its fatal termination on the night of the 18th December. The analysis of the serum is given in the table below.

"Case II. *Intensely Malignant Cholera.* Occurred in the Cholera Hospital, Sandgate, Newcastle, on the 21st December. The patient, James Dewar, aged 39, a sailor, of good habits and colossal frame, was attacked at 6 a. m., on board the smack Nimble, of Leith, with spasms, cramps, purging, and vomiting of the peculiar fluid, which I need not describe. At 9 a. m. he was brought to the Cholera Hospital. Soon after his arrival, he passed a copious characteristic dejection, which was preserved for analysis. He was then given a little ammonia. Another evacuation followed in about ten minutes, and was also set apart. When I saw this patient at 11 a. m., he was perfectly pulseless and cold, his face contracted, and of a tarnished silvery or fishy aspect; he suffered horribly from cramps, and uttered cries like one shouting through a barrel. It was, on the whole, the worst case but one that I witnessed during my stay in the infected districts. A little after 11 a. m., some blood was taken from an orifice in each arm, and about eight ounces, dark in colour and viscid in consistence, were with some difficulty obtained; the patient writhing about his bed so constantly, that the blood could not be preserved from contact with the atmosphere. This blood was also set aside for analysis. Before leaving the ward, I tested the dejections with yellow turmeric paper, and that passed before the ammonia was given, changed the colour of the paper to a deep permanent brown. I should add, it had been ascertained that he had taken no medicines previous to his admission into the hospital. Notwithstanding the most assiduous attention and active treatment, Dewar died the same day at 4 p. m. The serum and coagulum, when

[1] A few copies of this valuable pamphlet are, I believe, still to be obtained from the publisher, Mr. Highley, Fleet street.

carefully separated and weighed, were in the proportion of 43 serum and 57 crassamentum, by which an extraordinary loss in the aqueous portion of the blood was pointed out. The crassamentum was then examined, and found normal in the proportion of its ingredients, so that the addition of a certain quantity of water would have restored it to its original density, proportions, etc. The serum was of the specific gravity 1045, and was devoid of the least action on litmus or turmeric papers; it composition is seen in the table below. Under the microscope, no alteration could be detected in the structure of the blood disks."

Dr. O'Shaughnessy also analysed the blood of a patient, who was labouring under severe bilious and fæculent diarrhœa with vomiting, and the results obtained from the serum are seen in the table: the crassamentum was stated to be found quite normal in its ingredients and their proportions.

Table of Analyses of Serum in Health (Lecanu), *Bilious Diarrhœa, and Malignant Cholera* (Dr. O'Shaughnessy).

	Healthy standard (Lecanu).	Bilious Diarrhœa.	Malignant Cholera. Mrs. Barras.	Malignant Cholera. Dewar.
Specific gravity	1028	1028	1041	1045
Reaction	Alkaline.	Alkaline.	Neutral.	Neutral.
Water	906·00	921·75	854·00	866·80
Albumen	78·00	61·85	133·00	124·00
Urea	0·00	0·00	0·40	0·00
Organic matter, soluble in alcohol and water	1.69	5.20	4·80	4·00
Albuminate of Soda	2·10			
Fatty matters: Crystalline	1·20	1·90	1·40	1·23
„ Oily	1·00			
Chloride of Sodium and Potassium	6·00	5·00	4·00	2·17
Carbonate of Soda, Phosphate of Soda, Sulphate of Soda	2·10	2·30[1]		0·50
Insoluble Salts, Phosphates and Carbonates of Lime, Magnesia, and Iron	0·91	1·10	1·60[2]	0·70
Loss	1·00	0·90	0·80	1·50
	1000·00	1000·00	1000·00	1000·00

Dr. O'Shaughnessy also mentioned in his Essay, that he had examined the blood in two other cases; in one, the composition agreed, in every essential particular, with Dewar's blood (case 2); in the other, with that obtained from Mrs. Barras. The history of the first case was not known, the other patient's disease was of a protracted type.

After the publication of his Essay, Dr. O'Shaughnessy had the opportunity of making further experiments in London, and he found that the specific gravity of the serum, in four specimens, was as follows:

[1] The 5·00 and 2·30, in the second column, should be estimated together, as part of the phosphates, sulphates, and carbonate of soda were included under the figure 5·00.

[2] In the third column, the carbonate of soda only was stated to be absent, a small amount of sulphate and phosphate being included with the insoluble salts.

1st Case	1042·7	3rd Case.....	1047·0
2nd —	1054·4	4th —	1051·3

And the amount of colouring matter in the same specimens of blood, with the addition of the two Newcastle cases, estimated according to Prevost and Dumas' method, viz., by assuming the fluid portion of the clot to be serum, was—

1st Case	162·5	4th Case	147·0
2nd —	156·0	5th —	112·8
3rd —	164·3	6th —	136·0

We shall next speak of the analyses made by Dr. Thomson, of Glasgow. The relation he finds existing between the crassamentum and serum in Cholera blood, to a certain extent, gives us an insight into the amount of loss which the fluid portion of the blood has undergone; but it must be borne in mind, that the relation between these may be altered by other circumstances; for the clot consists of the blood corpuscles held together in the form of a mass by a very fine network of coagulated fibrine, enclosing also a certain amount of serum. Now the closeness or density of this clot may be modified by the physical condition, as well as the amount, of fibrine, which may possess very different degrees of elasticity and toughness; it may therefore form a soft and large, or a small and firm clot, even when the ratio between the solid and liquid portions of the blood remains the same,—much more serum being retained within its meshes in the former case. Again, the shape of the vessel, in which the blood is collected, may influence considerably the size of the clot: thus, in an experiment, when separate quantities of the same blood were drawn in a flask and in an open basin, the proportion of crassamentum was found to differ considerably, being in ratio of 13 in the flask to 21 in the open basin. If, however, care be taken to avoid these liabilities to fallacy, by using similar-shaped vessels, and noticing the density of the clot, we can, from such observations, arrive at conclusions which are tolerably correct.

Assuming, then, the ratio between the serum and crassamentum in healthy blood to be as 57 : 43, Dr. Thomson, in five specimens of Cholera blood, found the proportions as follows:

Case.	Serum.	Crassamentum.
1.	32·34	67·66
2.	32 00	68·00
3.	38.45	62·58
4.	35·66	64·34
5.	27.59	72·41

Here we see the ratio, existing in health between the serum and crassamentum, more than reversed. Dr. Thomson also further examined the serum, and found the specific gravity of the different specimens to be, in the

1st Case	1044·6 ..	pure yellow serum.
2nd —	1044·3 ..	slightly tinged red.
3rd —	1052·0 ..	very red.
4th —	1055·0 ..	very red.
5th —	1057·0 ..	very deep red.
Average healthy serum	1028.0	

He also estimated the water and solid coustituents of the serum in these different specimens of blood, and his results, compared with Dr. Marcet's analysis of healthy serum, are seen in the following table.

	Case.	Water.	Albumen, Salts, etc.
Healthy serum	—	900	100
Cholera serum	1	839·5	160·5
——	2	839·6	160·4
——	3	811·7	188·3
——	4	811·0	189·0
——	5	808·2	191·8

Dr. Thomson also attempted to discover the proportion of the albumen and salts in serum, No. 1; and then found, that of the 160·5 parts of solid matter, 150·15 consisted of albumen and 10·35 of salts, with which, however, he included the organic matter of the serum, which was soluble in boiling water, and therefore the figure 10·35 represents what is usually included under the head of salts and extractive matters. From this one analysis, Dr. Thomson calculates the ratio between the albumen and salts in the remaining four specimens of serum; this, of course, must be considered as a very unsatisfactory mode of proceeding, especially in examinations of blood in a disease, where it has by no means been proved that the different constituents of that fluid are always altered in the same proportion. Dr. O'Shaughnessy has attempted to deduce the amount of real salts from the analysis given by Dr. Thomson, but I think it unwise to do so, and we had better remain satisfied with such information as the experiments warrant us in arriving at. Again, with regard to the colouring matter of the blood in Cholera, Dr. Thomson has given his results, but his mode of analysis employed to separate the former substance is very faulty, and, consequently, unsatisfactory. As to the fibrine, I think we have other analyses on this point which can be more depended on.

Lastly, Dr. Clanny made several analyses of Cholera blood, and although the methods employed by him may not, perhaps, bear criticism, yet as they were compared with healthy blood, the composition of which was determined in a similar manner, some of the results are valuable; they show that, in Cholera, there is a loss of the watery portion of the blood; that the globules and other organic solids are increased; that the fibrine is usually diminished; and that the physical condition of the blood is also altered, by its becoming dark in colour and thick in consistence.

Besides the analyses which have been given above, many others were performed during the last epidemic, some as to the composition of the entire blood, others merely for the purpose of determining certain points. These I have thought it unnecessary to detail, for the chemistry of organic fluids was at that time very imperfect, (especially before the appearance of the admirable essay of Lecanu, entitled *Nouvelles Recherches sur le Sang*); and consequently but little confidence would at the present time be placed in some of the analyses. With regard, however, to the detection of urea in the blood of Cholera patients, I may observe, that it was found by Marchand, Heller, Simon, and Rainy; others were unsuccessful in the search; we have already seen that Dr. O'Shaughnessy detected it in the first case (Mrs. Barras), but not in the second (Dewar). Urea was also found in the bile, and by Dr. Christison in a serous effusion on the brain of a patient dying of Cholera.

On reviewing the analyses, which are given above, we shall be enabled

to form some general conclusions as to the condition of the blood in Cholera; but previous to so doing, I think it will be well to make some remarks on the detail of these analyses. And first, with regard to the physical condition of Cholera blood;—nearly all observers are agreed on this point, viz., that the consistence and colour are altered, that it becomes much more viscid than natural, and usually darker in colour and less coagulable; the extent, however, of these changes appears to depend much on the stage when the blood is drawn. Next, with regard to the alteration which it undergoes in composition.

Water. All the analyses given above, show that this portion of the blood becomes much diminished in quantity: this is seen from the experiments of Lecanu, Wittstock, Hermann, O'Shaughnessy, Thomson, and Clanny. There seems to be no discrepancy of opinion on this point; the same remarks apply, of course, to the increase of the solid constituents of this fluid.

Blood Globules or Red colouring Matter. Most observers have found that this portion of the solid matters of the blood becomes increased in amount; but others, as Dr. O'Shaughnessy, think that it is not necessarily increased beyond the normal standard; most of his results, however, show such an augmentation The different modes of separating this principle have, doubtless, led to much of the discrepancy observed in the analyses. Dr. O'Shaughnessy, in criticising the results obtained by Dr. Thomson, states, that the method employed by himself "shows precisely and infallibly the quantity of colouring matter"; but I think I have evidence sufficient to prove, that it is liable to very considerable error, and that the assumption, that the fluid contained in the clot is of the same nature as serum, is by no means correct.

Fibrine. From what we have seen above, it would appear that this principle is liable to great alteration in Cholera blood: in general (but not necessarily), it would seem to be diminished in quantity.

Composition of the Serum. All the analyses agree in showing that this part of the blood is especially affected in this disease. One of the most important alterations, which it undergoes, consists in the diminution of its watery portion, and consequent increase in its solid constituents, a change indicated by its high specific gravity. From the numerous observations on this point, we have found that it has varied between 1036 and 1057, the lowest 8, the highest being 29 points above the average weight in health—viz., 1028. It would also appear that there is a considerable tendency to its becoming less alkaline, and even neutral, in its reaction. (O'Shaughnessy).

Albumen. If we estimate this body in relation to the water of the serum, we find that its proportion is always increased in Cholera, and it is chiefly to this augmentation that the high density of the fluid is due; all the results given above show this fact; but if the albumen be estimated in the 1000 parts of the blood itself, then there are considerable discrepancies in the different analyses. The reason of this it is not difficult to discover; for, by the methods employed by some, a considerable amount of the albumen was included under the head of colouring matter, thereby increasing the figure of the latter principle, and diminishing that of the former. It is, however, easy to understand

how the albumen may be greatly increased in the serum, yet even diminished in the blood, taken as a whole; for the serous portion (including albumen) might be lessened in quantity, from intestinal evacuations, to such an extent, that the absolute amount of albumen in a given quantity of blood should be below the normal amount. I believe, however, as Dr. O'Shaughnessy has stated, that such was not the case in the blood examined at that period.

Salts. Concerning the alterations in the saline portion of the blood, very much has been written, and from the results obtained in some of the analyses, peculiar methods for the treatment of Cholera have been proposed and employed. It is therefore exceedingly important to examine this point, and see what value should be attached to the experiments, upon which the conclusion, as to great diminution of the salts of the blood in Cholera, is based.

If we examine the table given above, containing the results of the analyses of the serum in health by Lecanu, in a case of bilious diarrhœa, and in two cases of Cholera by Dr. O'Shaughnessy, we observe that Lecanu, in healthy serum, finds 8·1 parts of soluble salts in the 1000 parts of serum, of which 6 parts consist of chlorides, the remaining 2·1 parts of soluble phosphates, sulphates, and carbonates, which are not individually estimated. Dr. O'Shaughnessy, by employing the method of Lecanu, finds, in the first case (Mrs. Barras,) only 4 parts of chlorides, no carbonate of soda, and very small quantities of the sulphates and phosphates, which he estimates with the insoluble salts. In the second case (Dewar,) he finds a still smaller amount, only 2·17 parts of chlorides, and of soluble phosphates and sulphates, and carbonates, 0·5 parts: in the case of bilious diarrhœa, 5 parts of chlorides were found, and 2·30 of phosphates and sulphates, and carbonates. Granting the accuracy of these experiments, we should arrive at once at the conclusion, that, in Cholera, the saline portion of the serum undergoes a remarkable diminution. I may, however, mention, that when Dr. O'Shaughnessy made these analyses, the Essay of Lecanu had but just appeared, and that by the method adopted by this chemist for ascertaining the amount of salts, great care is necessary, and I might add, some considerable experience, to enable the experimenter to collect the whole of the saline matter; and I think that it is possible that the estimates given in the table may be below the real amounts which existed in those specimens of serum: still, however, in the case of bilious diarrhœa, the quantities nearly approached Lecanu's standard. I venture to suggest this, not from any desire to cast the slightest doubt on the accuracy of Dr. O'Shaughnessy, but from the circumstance of others not having found such deficiency in serum, which in other respects resembled that operated upon by him. That errors must exist somewhere in these analyses, I think can be shown from the fact, that the serum in the case of bilious diarrhœa, stated to be of specific gravity 1028, the same figure as that given by Lecanu for his standard serum, contained of solids, in all, 78·25 parts in the 1000, whereas Lecanu found 94·00; and to show that this difference did not depend on the different proportions of the organic and inorganic constituents, it is found, that not only were the total solids, but also both the organic and inorganic portions, in larger amount in the serum analysed by

Lecanu. Again, if we compare the serum of Mrs. Barras, specific gravity 1041, with that from Dewar, specific gravity 1045, we find that, although there is as much as four points difference in weight, both the organic and the inorganic portion of the solid contents of the former were greater than those existing in the latter. It is certainly impossible to explain these facts, except by assuming that some error existed in the analyses. Dr. Thomson came to the conclusion, that the salts were not diminished in Cholera blood; but, as stated before, the extractive matters were estimated with this portion, and therefore the separate determination of the salts can only be a matter of speculation. There is another reason for my supposing that the salts in Dr. O'Shaughnessy's analyses of Cholera blood may possibly be estimated too low; namely, that in two examinations of serum of specific gravity very much the same as that of case 2 (Mrs. Barras,) I failed to find such a diminution, although the experiments were repeatedly and very carefully performed; but of this we shall again have occasion to speak. With regard to the amount of salts in the remaining four specimens of serum, of which Dr. O'Shaughnessy ascertained the specific gravity, I am not aware that any estimation was ever made.

The conclusions, to be drawn from these researches, may be stated as follows:—

1. That in Cholera, the physical characters of the blood are altered, and that its tendency is to become thicker, tar-like, and less coagulable.
2. That the proportion of water is much diminished.
3. That the specific gravity of the serum is very high, which is due to the increase of the solid portion of the serum, and especially of the albumen; and that this fluid also tends to become less alkaline in its reaction.
4. That with regard to the salts of the serum, some doubt exists as to their excessive diminution.
5. That urea sometimes exists in Cholera blood.

At the end of the second part of our paper, we shall see whether any of these conclusions are affected by more recent analyses; and also, whether any further results can be with safety deduced.

II. RESULTS OF ANALYSES OF CHOLERA BLOOD MADE DURING THE PRESENT EPIDEMIC.

The analyses, which we are next about to detail, were made upon eight specimens of Cholera blood, in some of which, from their quantity or condition, only certain points could be determined with accuracy. Two of these analyses were performed by my friend Dr. PARKES, the remainder by myself; and I may again mention, that the want of more thorough investigation has been due, not to any lack of zeal in pursuing the subject, but to the great difficulty experienced in procuring the fluid for analysis.

It may be as well, before treating of these details, to mention some analyses of healthy blood, so that we may be enabled more readily to compare the results, which we may obtain in our examinations of the diseased fluid, with those observed in health. I will first give a table shewing the composition of the blood of healthy males and females, according to BECQUEREL and RODIER.

Composition of Human Blood. Adult Male in the 1000 *parts.*

	Mean.	Maximum.	Minimum.
Density of defibrinated blood	1060·2	1062 0	1058·0
——— Serum	1028 0	1030 0	1027·0
Water	779·0	800·0	760·0
Solids	221 0	240·0	200·0
Blood globules	141·1	152·0	131 0
Fibrin	2 2	3·5	1.5
Albumen	69·4	73·0	62·0
Extractives and free salts	6·8	8·0	5·0
Fatty matters	1·600	3·255	1·000
1000 *Parts of Blood after calcination yielded.*			
Chloride of sodium	3.1	4·2	2·3
Soluble Phosphates, &c.	2·5	3.2	2·0
Insoluble Phosphates, &c.	·334	·700	·225
Iron	·565	·633	·508

Human Blood. Adult Female in 1000 *parts.*

	Mean.	Maximum.	Minimum.
Density of defibriuated blood	1057·5	1060·0	1054·0
——— serum	1027·4	1030·0	1026·0
Water	791·1	813 0	773·0
Solids	208·9	227·0	187·0
Blood globules	127·2	137·5	113·0
Fibrin	2·2	2·5	1·8
Albumen	70.5	75·5	65·0
Extractives and free salts	7·4	8·5	6·2
Fatty matters	1·620	2·860	1·0
1000 *Parts of Blood after calcination yielded.*			
Chloride of sodium	3·9	4·0	3·5
Soluble phosphates, &c.	2·9	3·0	2·5
Insoluble phosphates	·354	·650	·250
Iron	·541	·575	·486

As these analyses very much accord with those made by myself on healthy human blood, I shall use them for the purpose of comparison. As regards the serum, we may take Lecanu's standard, which has been given in Part I; and I may state that, for the purpose of ensuring accuracy in the analyses of morbid serum, I have employed the same method, and obtained figures representing the proportion of the most important constituents of this fluid, as derived from a healthy patient.

This analysis is seen below.

Serum. Specific gravity 1027·9. Alkaline in reaction; contained in 1000 parts.—

Water	909·25
Solids	90·75
Albumen, Fatty and extractive matters	80·48
Soluble salts	9·34
Insoluble salts	0·93

The methods employed in performing these examinations of blood and of serum were as follows:

Analysis of Blood. The physical characters of the fluid were first noticed, also the reaction which it exhibited with blue and red litmus papers; the specific gravity was afterwards ascertained. If the blood was in such a condition that it would neither coagulate nor allow the globules to subside, a weighed portion was at once evaporated to dryness;

and, after it had ceased to lose weight by exposure for some little time to a temperature a little above 212° Fahrenheit, the amount of the solid residue was ascertained: by this operation, the *water* and *total solids* were obtained. The residue was then carefully burnt in a platina crucible; and, after the charred mass had been exposed to a red heat for a short time, and it had ceased to give off any odour, the weight of the black mass, consisting of the inorganic constituents together with carbon, was ascertained; it was then boiled several times in distilled water, for the purpose of removing all the soluble salts, and thoroughly dried and reweighed; the loss indicating the quantity of soluble salts, with the exception of a small amount, which is retained very strongly by the carbon. The carbonaceous mass was then exposed to a bright red heat for some little time, until all the carbon had been burnt off; the residue consisting of the insoluble salts, with a trace of the soluble salts spoken of above: these were separated by washing, and their quantities ascertained. All the numbers were then reduced to the 1000 parts. In analysing the serum for its saline constituents, the method above detailed was employed, and the albumen afterwards determined from a separate portion. The blood globules were estimated according to the method of Prevost and Dumas, or of Becquerel and Rodier. The fluid contained in the clot was regarded as serum. The urea was estimated by exhausting the dried blood with alcohol, and adding strong nitric acid to a concentrated watery solution of the alcoholic extract. The presence of uric acid was determined, by exhausting with water the dried blood, which had been previously acted upon by alcohol, for the purpose of extracting the urea, and then employing the murexide test, or precipitating the uric acid by the addition of acetic acid to the concentrated watery solution.

Case I. The first case occurred in one of the Tooting children, Michael Harper, ætat. 9; he was seized about nine o'clock P.M., and died on the following day about half-past one P.M. Having passed one very copious evacuation, and another more scanty, he sank into a state of collapse; before death, the rice-water fluid had soaked through the bed; he vomited at intervals during his illness, and the urine was probably suppressed. A *post-mortem* was made thirty-eight hours after death.

General Appearances. Rigidity was present in the jaw and in all the large joints, but not so well marked in the toes; the surface of the body was not livid, but had a mottled appearance; the nails of the left hand, however, were livid; the teeth were covered with sordes; the body weighed forty-five pounds avoirdupois.

Head. On opening the head, the large sinuses of the dura mater were found filled with blood; the veins of the pia mater were also turgid, so as to give the brain a congested appearance. On making a section of the brain, the distinction between the grey and white matter was strongly marked; in the latter the red points were pretty numerous, in consistence both were normal; a very small amount of fluid was found in the lateral ventricles. Weight of the cerebrum, 42 oz.; of the cerebellum, 5 oz.; of the medulla oblongata and pons Varolii, 6 drachms. Nothing remarkable was found, on making sections of these different parts. The sinuses at the base of the skull were full of blood.

Thorax. On opening the chest, the lungs were found universally

adherent, the adhesions being tough, and doubtless produced by old pleuritic inflammations. The right lung was of small volume, sparingly crepitant; on section the colour was dark, the substance firm but not hepatized, and it did not contain much blood or serum; there was no consolidation at the apex, nor were tubercles found throughout the substance; the bronchial tubes contained some frothy mucus. The left lung was lighter in colour than the right, but still of a deep red; on pressure, much blood exuded from the small vessels, particularly from the inferior and depending portions; no tubercles were observed; the bronchial tubes contained a little frothy mucus. The larynx and trachea were healthy, and exhibited but slight vascularity.

Heart, &c. The pericardium was healthy, and contained no fluid. The heart weighed four ounces and two drachms; the right auricle was much engorged, and contained a large but partially decolorized clot; the right ventricle contained a large colourless, very soft coagulum; in the left ventricle was found a small colourless coagulum. The substance of the whole organ was healthy.

Œsophagus, &c. The mucous membrane of the pharynx and œsophagus was natural.

Stomach. The peritoneal surface was pale, the mucous membrane but very slightly vascular, not softened, containing a small quantity of a thickish dark brown fluid, smelling of port wine—about ʒiv. in quantity.

Small Intestines. The peritoneal surface had a tolerably well-marked vermillion tint. In the duodenum the glands of Brunner, and also the solitary glands were enlarged. In the ileum, the solitary glands were also strongly marked, and Peyer's glands elevated and red in colour.

Colon not contracted; its peritoneal surface was pale, and the glands were enlarged in the ascending portion. In the descending and transverse portions, the mucous membrane was pale.

Liver. Weight twenty-one ounces, two drachms; was adherent to the diaphragm over the greater portion of the right side. The gall bladder was moderately distended with bile of a deep green colour, and of viscid consistence.

Spleen weighed two ounces and six drachms, and appeared healthy in structure.

Kidneys. The right weighed two ounces and two drachms, the left two ounces. In both, the substance was healthy, and the capsule easily separable.

The Bladder was quite empty and very firmly contracted (like a ball).

The blood in the sinuses of the brain, heart, and large vessels, was not coagulated, but had a consistence and appearance not very unlike tar.

The mesenteric glands were not enlarged, the omentum contained but a very small quantity of fat, and on the walls of the abdomen a layer of that substance was found, not measuring more than one-fifth of an inch. In the small intestines was contained some fluid, of the consistence of gruel, and about three or four ounces in quantity, which possessed an alkaline reaction, and under the microscope presented the appearances which are exhibited by the rice-water evacuations of cholera

patients, the deposit consisting of cylindrical epithelium scales, organic globules, etc. The contents of the intestines were, however, much thicker than the watery evacuations usually passed during life, but were similar to those, which have frequently been found after death in cholera patients.

On allowing the thick fluid to remain for some time in a glass, it separated into two parts, the clear portion being uppermost. This was found to contain a large amount of albumen, but no trace of *bile*. It did not give the pink tint which cholera stools frequently exhibit when treated with nitric acid, but this I have found to be not unusual in the latter stools passed by cholera patients. The blood was of a very dark colour, but became slightly reddened by exposure to the air. It did not coagulate; but, on minute examination, small specks were found in it, consisting of very soft fibrine; when allowed to remain at rest for some hours, the blood scarcely exhibited a layer of serum on its surface, and it would not pass through coarse filtering paper, as is the case generally with this fluid. Under the microscope, the globules were seen to be very numerous, and some irregular in shape. Specific gravity of the blood 1076.5, at 45° F.; reaction slightly alkaline.

Composition in 1000 parts.

Water	729
Solids	271
Blood globules, Albumen, &c.	260·2
Soluble salts, Insoluble ditto	10·8

No urea was detected; traces of uric acid were however found, which would probably indicate the presence of urea also; but the amount of blood used for this experiment was small. I may remark that the quantity used, to determine the salts, was likewise very small.

Another analysis was made of the top portion of the same blood, after a partial subsidence of the blood globules had taken place, and in 1000 parts it was found to contain:

Water	851·4
Solids	248·6
Blood globules, Albumen, &c. &c.	233·
Soluble salts	12·6
Insoluble ditto...	2·1

Here we find, that when more serum was present in the blood, the soluble salts were greatly increased and the insoluble decreased, at the same time that the total solids were diminished: hence, if the serum could have been separately determined, it would doubtless have shown a very large proportion of salts

Case II. The second case also occurred in one of the Tooting children, James Andrews, ætat. 6 years. He was suffering from diarrhœa when removed from Tooting, and at half-past six in the following morning was seized with vomiting and collapse, and died at half-past eleven. The evacuations were characteristic, but their amount not ascertained. He was stated to have been purged five or six times.

The *post mortem* was made 140 hours after death.

General appearance. Rigidity nearly gone off in the lower extremities, quite so in the jaw and upper extremities; the surface not livid, but mottled, with red patches, with the exception of the abdomen, which had a yellowish green appearance. The nails of the fingers and toes were livid, the skin of the soles of the feet was wrinkled; the body had not undergone any decomposition, although death had occurred so long before.

Head. The sinuses of the dura mater contained some thick dark-coloured blood, and the veins of the pia mater were full of the same fluid. In the substance of the brain, the grey and white matters were well contrasted. Very small amount of fluid in the ventricles. The cerebellum and medulla appeared quite healthy.

Chest. The pleura was very slightly adherent at the left side, and at the base of the right lung, which was slightly congested, but intact; left lung very slightly congested; no tubercular deposition. The bronchial glands were rather enlarged.

Heart. No polypi were found either in auricles or ventricles, but a very small thread-like and whitish coagulum in the first portion of the aorta, the consistence of which was soft. The heart was of the natural size, and the substance healthy.

On making a section of the abdominal walls, a layer of fat, about one-fifteenth of an inch, was found, and the omentum scarcely contained any of that substance. The mesenteric glands were considerably enlarged, and contained deposits of tubercular matter.

Stomach. Peritoneal surface healthy. Mucous membrane not softened, but stained red in patches. A small quantity of a thickish fluid was found in the cavity of the organ.

Intestines, &c. The peritoneal surface of the small intestines had a vermillion tint, from the injection of the small blood vessels. The mucous membrane was not softened; in the lower portion of the ileum, the solitary glands were very prominent. A small quantity of a thickish white matter was found on the surface of the mucous membrane, which exhibited the same appearances under the microscope, as that found in the intestines of the last case. The large intestine presented a greyish white appearance on its peritoneal surface, and its mucous membrane was healthy.

Liver, etc. Substance of this organ healthy; gall-bladder filled with bile, of moderate consistence, and of a yellowish brown colour. Spleen healthy.

Kidneys. Quite healthy; the urinary bladder strongly contracted.

The blood was of similar character in all parts of the body; that found in the heart and large vessels was used for analysis. It was of a dark colour and treacle-like consistence; the specific gravity was not ascertained, on account of the small quantity procured. The globules did not subside when the fluid was allowed to rest, and minute specks of fibrine were observed floating in it.

Composition.	Water		724·5
	Solids		275·5
	Globules, albumen, etc		262·0
	Salts—Soluble	10·7	13·5
	.. Insoluble...	2 8	

Urea was not detected; a small quantity of uric acid, however, was crystallised, perhaps a little exceeding in amount that found in health; but for these determinations, as well as for the saline constituents, only a small portion of blood was employed.

For the two following observations and analyses, I am indebted to Dr. Parkes.

Case III. Blood taken from the heart and pulmonary arteries of a young woman, who died in the cold stage of Cholera. It had a dark colour, was thick in consistence, but not coagulated; it did not separate into clot and serum, but had small masses of fibrine and coagula floating in it. It was not certain whether the whole of the fibrine had been removed from the vessels. When exposed to the air, the blood became in part arterialized; but there were many small portions or coagula, which, after twenty-four hours' exposure, remained as black as at first. The *reaction* was alkaline. The fibrine was estimated by washing a weighed portion of the blood, in which the small clots were equally diffused by shaking. There was no difficulty in washing the fibrine quite white; if anything, this was done more easily than usual. In evaporating the blood to get the proportion of solid contents, it was remarkable how easily the drying mass was broken down, and how pulverulent it became, under much slighter pressure than is sufficient to break down healthy and inflammatory blood. As the ingredients of the blood were so mixed up together, it was impossible to do more than estimate the fibrine, the albumen and globules together, the insoluble and soluble salts, and to examine for urea and uric acid. Specific gravity (of whole blood), 1076·22; temp. 62°.

Composition.	Water		729·07
	Solids		270·93
			1000·00
Fibrine		·88	
Red particles and organic solids of serum		262·61	
Soluble salts		6·15	
Phosphate of lime, phosphate and free oxide of iron ..		1·29	
		270·93	

The solution of the soluble salts was alkaline; their amount was over the figure stated above, as there was a trifling loss; that given was absolutely weighed. The quantity of each salt was not determined; but there was, as is usual in healthy blood, a great excess of chlorides. The precipitates of the ammoniaco-magnesian phosphate and the sulphates seemed to be in about the usual quantity.

Examination for urea and uric acid. A portion of pulverized blood was thoroughly digested in repeated quantities of alcohol; the alcohol distilled off, and the residue dissolved in a little distilled water; it was evaporated slowly to a syrup, and a little nitric acid added. After thirty-six hours, no crystals had formed. The blood which had been treated with alcohol was now boiled thoroughly with distilled water; the solution was evaporated; the residue, re-dissolved, evaporated to a very small bulk and treated with hydrochloric acid. After forty-eight hours, no crystals of uric acid had been deposited.

It appears, therefore, that if urea and uric acid were present, they were not in any great quantity. A possible inaccuracy may have occurred in the analysis for urea, as at one time the alcoholic solution was distilled too rapidly, and the urea may have been decomposed. The quantity of fat taken up by the alcohol seemed to be considerable; it was not weighed.

Case iv. Blood from the venæ cavæ of a woman, who died in the cold stage of Cholera. It presented the same physical characters as in the former case; small masses of clot floated in a thick red fluid. The reaction alkaline, but not so strongly marked as usual. Specific gravity 1068·16; temp. 45 Fahr.

Composition.	Water		748·46
	Solids		251·54
			1000·00
Organic constituents of blood		244·263	
Soluble salts		5·72	
Perodide of iron		·884	
Phosphate of lime		·673	
		251·540	

It was not analyzed for urea or uric acid.

Case v. With regard to the next case, it may be well to state, that, as the patient's symptoms during the progress of the disease, the stools passed at the different periods, also the blood abstracted during life, and that found in the vessels after death, were carefully examined, it has been considered advisable to go somewhat into detail, for the purpose of endeavouring to give as complete an account of a case of Cholera a is at present on record. Dr. Parkes undertook the examination of the stools; the analyses of the blood were made by myself: the patient was under the care of Dr. Williams.

William Worts, æt. 39, native of Wicklow (Ireland), admitted into University College Hospital Feb. 1st, 1849, had been a sailor since the age of twelve years; a strong, stout man, having enjoyed good health, but at times had been addicted to hard-drinking About a month previous to his coming to London (Jan. 28th), he had lived in Liverpool, in a house near the side of the river, and during that period had been very intemperate, and consequently had taken but little solid food. On his arrival in town, he lodged in an inn near the Euston-square railway terminus, and the same night was intoxicated. The next day, Jan. 29, he became cold and shivering, for which he took some spirits; he felt very unwell all that day, vomited several times, and during the night had some pain in the abdomen, and diarrhœa. These symptoms continued during the whole of the 30th, on which day he took no solid food; slight cramps were felt in the calves of the legs at night, when the purging and vomiting became more violent, and the thirst intense, to relieve which he took a large quantity of water. On the 31st, and up to the middle of the next day, Feb. 1st, the above-mentioned symptoms continued unabated, and the cramps increased in intensity.

On admission, at two o'clock, p.m., he was extremely feeble; the hands and face were of a dusky hue, eyes a little sunken, surface warm, pulse 120, but extremely weak; tongue dry, covered with a brown fur

in the centre, but white at the edges. Had been purged several times during the last hour, the stools containing some bile-pigment; vomiting incessant, cramps in arms and legs, voice peculiar; has not passed more than half a pint of urine for the last twenty-four hours.

4 P.M. Feels very cold, face and hands rather more livid, quite dry. Since two o'clock he has passed three stools, still containing bile-pigment; breath becoming cool, and respiration hurried.

8 P.M. Has had only two stools. Pulse rather stronger and surface warmer, thirst continues excessive; has drank seven quarts of toast and water.

11 A.M. Passed a stool, which had the following characters and composition. It separated into two parts, fluid and sediment; the latter rather bulky. The fluid portion was not filtered, but removed by decantation, and had a slightly turbid appearance, and a peculiar faint odour. Reaction, *alkaline;* sp. gr. 1010·3 at 56° Fahr.; with nitric acid and heat, no change of colour was observed, until a considerable quantity of acid had been added, when a slight yellow tint appeared, and a tolerably copious precipitate was thrown down. A trace of uric acid was detected by the murexide test.

Analysis.		
Water		984·22
Solids		15·78
		1000·00
Coagulable organic matter (albumen)	1·9	
Incoagulable organic matter	7·7	
Soluble salts—Chlorides, Phosphates, Sulphates, etc.	6·15	
Insoluble salts (Phosphate of lime, etc.)	·03	
	15·78	

Dr. Parkes remarks, that the high figure of the solids must be in part attributed to the fluid not having been filtered, as it was thought to be too thick.

Feb. 2nd, 1 A.M. Pulse 100, very small, at times almost imperceptible; respirations 26 in the minute; surface cold and dry; tongue and breath cold; skin of hands slightly wrinkled. About four ounces of blood were taken from the arm; after which the pulse became 120, and the respirations 32 in the minute; temperature in the groin 86° Fahr. The blood presented the following characters. It was certainly more viscid than healthy blood, and flowed with some difficulty from the veins; one portion was set aside, in which coagulation took place in a few minutes, and, after a time, a tolerably consistent clot was formed. Another portion was whipped to separate the fibrine. By exposure to air the fluid became slightly reddened, and under the microscope no abnormal appearances were observed. Density of defibrinated blood, 1076 at 50° Fahr.; of serum, 1040 at 60° Fahr.

Composition in 1000 *parts.*		
Water		717·5
Solids		282·5
		1000 00
Blood globules	166·00	
Fibrino	2·61	
Albumen	103·50	
Extractive fatty matters, salts, etc.	10·39	
	282·5	

The salts, determined by burning, were found to be, in 1000 parts of blood, 8·32 parts. The soluble and insoluble salts were not separately determined. Urea was found, and in the 1000 parts of blood amounted to 0·38 part. The serum had a slightly reddish tint, a reaction but slightly *alkaline*, specific gravity 1040, and in 1000 parts contained—

Water		862.9
Solids		137·1
		1000·0
Albumen	125·40	
Extractive and fatty matters	2·54	
Soluble salts	8·12	
Insoluble ditto	1·04	
	137·1	

The chlorides separately determined, by direct weighing, amounted to 5·41 parts, and consequently the soluble phosphates, &c. to 2·71 parts.

5 A.M. Pulse 120; respirations 28. Very restless; complains much of exhaustion and pain in the body; has intense thirst, and has taken eight gallons of toast water since 1 o'clock: vomiting continues; breath decidedly cold. He passed one stool about half-past two, which, on examination, gave the following results. It was thicker than the last, not readily separating into two parts; the flaky matter was very abundant, and gelatinous in appearance. The fluid portion, with great difficulty strained through muslin, was white and opaque, of the usual faint odour, and *strongly alkaline* reaction. Specific gravity 1014·5 at 56° Fahrenheit. With heat and a few drops of nitric acid a precipitate fell; a few more drops of acid gave a light pink tint, which was destroyed by additional acid. No bile could be detected by Pettenkoffer's test. (The fluid, however, and not its alcoholic extract, was used in the experiment.)

Analysis. Water			976·2
Solids			23·8
			1000·0
Coagulable organic matter (albumen)		2·93	
Incoagulable organic matter		10·93	
Soluble salts		8·24	
Insoluble salts		1.70	
		23·80	

Dr. Parkes remarks, that the large proportion of incoagulable organic matter in this stool, as in all the others, was evidently owing to the fact, that the fluid was very turbid, and was not filtered, or rather, would not pass through filtering paper. It is worthy of note, however, that the phosphate of lime is, in the analysis of the second stool, much more abundant than in that of the first; and this seems to have some relation to the quantity of incoagulable organic matter.

7. A.M. Surface rather warmer; pulse 130, scarcely perceptible; respirations 33; has had less cramp, and feels easier. A stool was passed between seven and eight: still thicker than the last; of a yellowish brown colour, and in quantity about three ounces. It did not separate into two parts, but the sediment remained suspended; by greatly heating it, however, the sediment was partially thrown down. The stool was esti-

mated as a whole. Odour peculiar, slightly fæculent. Reaction markedly *alkaline*. Specific gravity 1017·2. Temperature 56° Fahrenheit.

Composition of fluid and sediment together.

Water	964·78
Solids	35·22
	1000 00

The organic matter, soluble salts, and phosphate of lime, were not determined. The solution of the dried solids was alkaline, like the stool.

Another small stool, passed about a quarter past eight, only one ounce and a half in quantity, was of a brownish yellow colour. Not further examined.

11 A.M. Pulse 120; stronger, has no pain, and is less restless; has passed one stool, about three ounces; whiter in colour than the two last, but still very thick. After twenty-four hours it had partially separated into a fluid and a bulky sediment, which consisted of a yellowish gelatinous looking matter, having white flakes distributed through it.

1 P.M. Pulse 110; respirations 22; temperature of mouth 87° Fahrenheit, of axilla 93°, of groin 94°; complains of burning heat at the epigastrium, and vomits frequently. He passed a stool about twelve, not more than two ounces in quantity, much thinner than the three last, and partially separating into a fluid and sediment: fluid opaline and turbid; sediment flocculent. Reaction strongly alkaline: odour as usual, or slightly fæculent. The fluid, strained through muslin, was very turbid. Specific gravity 1014; temp. 60°. The liquid became turbid by heat. On adding a few drops of nitric acid, there was no change of colour, but a precipitate appeared. A few more drops gave a light red tinge; again adding a few drops increased the colour; but a great excess diminished its intensity, yet did not destroy it.

Composition.

Water	986·52
Solids	13·48
	1000·00

Coagulable organic matter	3 50
Incoagulable and phosphate of lime	1·98
Soluble salts	8·00
	13·48

The soluble salts seemed to contain an unusual proportion of the phosphates, judging from the precipitate of the ammoniacal magnesian phosphate and the yellow phosphate of silver: the quantity was not determined.

7 P.M. Pulse 120; not so weak as before; breath much warmer; temperature of mouth 90°; of axilla 95°; has vomited some green fluid; stools passed at 2 p.m. and at 5. That passed at two o'clock was more copious than the last, and consisted of a turbid yellowish fluid with large white flakes, partly suspended and partly separated. Reaction strongly alkaline. That passed at five o'clock was much thicker, and did not present the rice-water character, nor separate into two parts. It was of a dirty yellow colour, mixed with white flakes. Reaction, slightly alkaline.

11 P.M. Improving: pulse stronger; surface warmer: has passed two stools between eight and half-past ten. The first was much more

consistent, almost uniformly brown, with a very few whitish or yellowish flakes; not copious. Reaction, alkaline. The latter was still more consistent than the previous stool, and had a distinctly fæculent smell; colour brown. Reaction, still decidedly alkaline.

February 3rd, 10 A.M. Pulse stronger; skin warmer; still very thirsty; and continues to vomit: the fluid from the stomach always showed a strongly acid reaction, and at this time was of an apple-green colour. Specific gravity, 1003; and a stool passed at 4 a.m. was of tolerable consistence, brown colour, and fæculent odour. Reaction, alkaline.

2 P.M. Thirst much less intense; vomiting much abated; fluid still green in colour; surface warm, and of its natural colour: pulse 108: bowels have not been acted upon since 4 a.m.

10 P.M. Pulse 104, weak: skin and breath cold: complains of great weakness.

February 4th, 4 A.M. Pulse intermittent; face and hands cold; skin shrivelled and with a blueish tinge.

7 A.M. Face of a purple hue; pulse very weak and intermittent; no purging.

2 P.M. Has rallied a little: pulse 108, moderately firm.

11 P.M. Has again become cold; the surface moist, and the pulse extremely weak: the bowels were acted upon in the evening; the stools were fluid and dark-coloured.

February 5th, 10 A.M. Continues cold: face and hands of a dark hue. In the afternoon he was sinking: pulse not perceptible, and the surface covered with a cold sweat. In this state he continued until half-past nine in the evening, when he died.

Sectio Cadaveris, 18 *hours after death.* Slight discolouration at the posterior parts of the body: fingers and toes contracted; on section, the blood flowed slowly from the vessels, was thick and dark in colour; the textures appeared deficient in moisture. On opening the chest, the lungs collapsed moderately; the omentum was loaded with fat; the stomach and large intestines were filled with gas; the small intestines were contracted: the body was very free from disagreeable odour.

Chest. The *larynx* and *trachea* were a little congested, especially in the posterior wall. The *right lung* was engorged and dark in colour, mostly at the back part: the blood being contained chiefly in the large vessels: it floated in water. The *left lung* presented a very similar appearance to the last, with the exception of a slight puckering and consolidation at the apex: the mucous membrane of the bronchial tubes was injected, with ecchymoses, and lined with a viscid mucus streaked with blood.

The *Heart* was flabby in its substance; all its cavities collapsed. The left ventricle was healthy; the right contained a soft fibrinous coagulum: the mitral, tricuspid, and semilunar valves were healthy; the aorta was filled with dark-coloured non-coagulated blood.

Œsophagus. The mucous membrane of the pharynx and œsophagus presented a congested appearance, especially at the lower portion.

The *Stomach* was lined with a yellowish green mucus. The surface of the mucous membrane was congested; and, in some spots, a slight extravasation of blood had taken place; the rugæ were prominent. The mucous membrane of the *duodenum* was stained with bile, slightly congested, and Brunner's glands were much enlarged. In the upper part of

the jejunum, the villi were slightly enlarged, and lower down were a few white patches, which appeared like ulcers under a lens; this portion of the intestine was filled with a yellowish mucus. In the lower portions of the ileum, there were a few points of ulceration in Peyer's glands. The peritoneal surface of the small intestines was congested in certain parts; the mucous membrane of the large intestines presented, here and there, patches of congestion, but was not softened.

The *Liver*, on section, showed a little congestion in the hepatic venous system. The gall-bladder was full of bile, of a greenish brown colour, very thick consistence, but not tenacious, as sometimes occurs from the presence of a large amount of mucus: it was neutral in its reaction. Specific gravity, 1044, being much higher than the bile usually found in the human gall-bladder.

The *pancreas* and *spleen* presented no peculiarities. The *kidneys* appeared healthy; so likewise did the bladder, which contained no urine.

WEIGHT OF ORGANS.

Right Lung	17 oz.	Pancreas	4½ oz.
Left ditto	22	Spleen	3½
Heart	14	Right Kidney	6
Liver	59	Left ditto	7

The blood examined after death was taken partly from the aorta, and partly from the vena azygos. It was of thick consistence and dark in colour. Reaction, *distinctly acid*. Specific gravity, 1081·8 at 50° Fah.

Composition in 1000 *parts.*	Water	715·2
	Solids	284·8

Blood globules	171·4
Fibrine	traces.
Albumen, Extractives, fatty matters, and salts	113·4

On incineration, 1000 parts of blood yielded—

Soluble salts	7·54	10·43 parts.
Insoluble salts	2·89	

1000 parts of blood contained 0·92 part of urea.

The *serum* obtained from the blood found in the aorta, was of a yellow colour, transparent, distinctly acid in its reaction, the acidity remaining permanent during the evaporation, and the watery solution from the dried matter exhibiting the same phenomenon. Specific gravity, 1039 at 50° Fahrenheit.

Composition in 1000 *parts.*	Water	863·10
	Solids	136·90

Albumen, Extractives, fat, etc.	127·84
Soluble salts	7.43
Insoluble ditto	1·63

Case VI. The patient, a married woman, æt. 30 years, was a nurse in the Royal Free Hospital, under the care of Dr. Peacock, from whom I received the blood, and also the following short account of the symptoms. She had been suffering from diarrhœa for two days, when, on the 18th of January, she was seized, at half-past two o'clock in the morning, with vomiting, purging, and cramps; by nine o'clock the collapse was extreme, and continued for about thirteen hours, when she rallied somewhat. From this time she lay in a semi-comatose state,

and died convulsed in the morning of the 21st, at half-past two, nearly seventy-two hours after the accession of the severe symptoms. The urine was suppressed for many hours, but she passed quantities with the stools during the last period of her illness. The stools were not very copious at first; latterly, they were bilious, dark-coloured, and offensive. The post-mortem appearances were those ordinarily met with, when some hours have elapsed since the seizure, and partial restoration of the circulation has taken place.

The blood was thick and dark-coloured, and contained threads of soft fibrine floating in it; no separation of serum took place. Reaction was *very slightly acid*. Specific gravity, 1074·8.

Composition in 1000 *parts.*		
Water		740
Solids		260
Blood globules, albumen, etc.	250·64	
Soluble salts	6·02	
Insoluble ditto	3·34	

On examining for urea, this principle was found in considerable quantities; the uric acid also existed in quantities greater than in health. 1000 parts of blood yielded 0·65 part of urea.

Case vii. The last specimen of blood of which we shall speak, was obtained from a patient under the care of Dr. Miller, to whom I am indebted for the opportunity of making the examination. The patient, a man, was suffering from fever consecutive to Cholera, and the blood was taken from the loins (by cupping) fourteen hours before death. The details of the case were published by Dr. Miller in the *Lancet*, Nov. 4, 1848.

The blood had separated into clot and serum. The clot was almost as firm as usual. The serum was clear, of a yellowish tint, darker in colour than usual. Reaction, neither acid nor alkaline to test papers. 1000 grains of serum yielded 1·142 grains of urea, and 0·038 of uric acid. The specific gravity of the serum was not determined.

We will now shortly review the results, which have been arrived at by the analyses recently made, and see how far they accord with those which were given in the first part of our paper.

Physical condition of Cholera Blood. As far as this point is concerned, all recent observations agree with those formerly made, and indicate, that, from the commencement of the disease, this fluid becomes more tenacious, of a darker colour, with less disposition to coagulate, and that its specific gravity is very greatly increased. It will be found by reference to the tables, giving the results of Becquerel and Rodier's examination of the blood of men and women, that the maximum specific gravity in the male is 1062, in the female 1060. Now, in our Cholera cases, we have found the specific gravity in adult males to be, in round numbers, 1076 and 1081, and in females 1068, 1074, and 1076; also, in children under ten years of age, in whom the blood probably has a specific gravity not exceeding 1045, we have found it as high as 1076 in one case, and in the second it was doubtless even higher (for it contained more solid matter), although the small quantity of the blood did not allow it to be accurately determined. We have thus proved, that, in Cholera, this property of the blood is greatly altered.

Water and Solids. Of course, the watery portions of the blood experience a diminution; nearly corresponding to the increase of the specific gravity of the fluid, and the solids a corresponding increase. In the table above referred to, the maximum amount of solids in males was 240, and in females 227, parts in the 1000 of blood; in children it is very much less. In our Cholera cases we have found that the numbers representing the total solids were 251, 260, 271, 271, 275, 282, 284.

Blood Globules. These we have also found to be increased in quantity, in the case in which we have been enabled to separate them from the albumen; and in place of 140 parts in the 1000 (which is considered a very high healthy average), we have found them to form 166 and 171 parts.

Fibrine. In the case (Worts), where the blood coagulated pretty firmly, 2·61 parts of fibrine were obtained in the 1000 parts of blood; in Dr. Parkes' case 0·88; but I remarked that the fibrine in Worts' case, although exceeding in quantity the normal average (2·20,) was yet much less consistent than natural in character. After death, the blood of this man did not coagulate at all, and I think it is probable that in Cholera this element of the blood undergoes changes of quality, rather than of quantity, and that as long as it can be ascertained correctly, analyses do not indicate any marked deficiency; after a time, however, it can no longer be collected.

Serum. As to the specific gravity of this portion of the blood, our observations were only two in number, and these were obtained from the blood of the same patient, at different times; both of them tend to confirm the results previously found; namely, that this fluid becomes much heavier, from the large increase in the amount of its solid constituents; healthy serum being of specific gravity 1028, we found it in Cholera to be 1039 and 1041.

Albumen. This constituent of the serum was only estimated in two cases, and in these amounted to about 125 parts in the 1000 parts of serum, and to 103 parts in the 1000 of blood; so we see that it is increased in both fluids. This we might naturally expect, when we take into consideration the character of the stools in this disease; for in them, we find that, compared with some of the other ingredients of this fluid, the albumen is thrown out in very small proportions; and although the ratio between the serum and clot is diminished, yet the decrease in the water more than counterbalances the loss which the albumen sustains.

Salts of the Blood and Serum. On this point our results have far from accorded with those obtained by Dr. O'Shaughnessy, and upon which so much stress has been frequently laid; we will therefore dwell a short time to consider the facts which have been elicited. Becquerel and Rodier found that the maximum amount of soluble salts in the 1000 parts of blood was, in the male 7·4, the minimum 4·3, the mean 5·6 parts; in the female, maximum 7·0, minimum 6·0, and mean 6·8 parts. We have found in our Cholera cases, that, where the soluble salts were separately estimated, they were represented by the numbers 10·7, 7·54, 7·5, 6·15, 6·02, and 5·72 parts in the 1000 parts of blood; every number exceeding the mean, and many the maximums obtained by Becquerel and Rodier from the healthy

blood both of males and females. The analyses were performed in the same way. Again, with regard to serum in health, in Lecanu's standard we find 8·1 parts in 1000; in a specimen of healthy serum (analysed by myself for the purpose of comparison), 9·34 parts, and in Becquerel and Rodier's table, when estimated in 1000 parts of serum, from about 6 to 8 parts. In the serum of Cholera we observe 8·12 and 7·43 parts; in neither case less than the mean of numerous analyses of healthy serum; and it should be borne in mind, that when the specific gravity of the fluid is high, from the increase of the albumen, as happens in cholera, the estimation of the salts in the 1000 parts of *serum* or *blood* is scarcely correct (for we should rather find the ratio existing between the *water* and soluble salts): if this is done, then, from our experiments, the amount of salts, instead of being *decreased*, as supposed by Dr. O'Shaughnessy, will be found always *increased*. It is curious to remark the composition of the blood in Cases I and II.; the subjects were children under ten years of age, in whom the disease proved rapidly fatal. In both specimens of blood, the soluble salts were very greatly increased; in that from the younger child, they were nearly twice the amount found in health. I should have been almost inclined to doubt the accuracy of these analyses, as they were made on very small quantities of blood, but on looking into my note book, every step appears to have been correctly performed; and, to confirm their accuracy, the third analysis made on the top portion of the blood (much more fluid being used in the operation), shewed a still greater increase of these salts, due to the presence of a larger quantity of serum in a given weight of blood. It would have been extremely interesting to have known the composition of the stools passed by these children, to have seen whether or not the ratio between the water and soluble salts was increased, In Dr. Parkes' paper on Intestinal Discharges in Cholera (*London Journal of Medicine, No. II,*) it will be observed, that the stools passed by children, 10 and 11 years of age, contained in the 1000 parts a smaller amount of the salts than those discharged by adults; and it is possible that there may exist some difference in the mode of action of the poison in children and adults: a difference in the symptoms certainly does exist.

It has been noticed in the cases now referred to, as well as in those spoken of in Part I, that the blood often became neutral, in some cases even acid. Dr. O'Shaughnessy considered this as depending on the blood losing its carbonate of soda, to the presence of which its normal alkaline reaction was referred. At the present time, however, the existence of this salt, even in healthy blood, is denied by many; and certainly many of the properties of the serum, formerly ascribed to it, depend on the tribasic phosphate of soda, which, when it contains two atoms of fixed base, possesses an alkaline reaction, and has the power of holding carbonic acid in solution. That this alkaline salt is not deficient, even when the blood shews a decided acid reaction, was clearly proved by our finding that the ash from such blood or serum exhibited alkaline properties, quite as strong as that obtained from these fluids in health.

The nature of the acid which existed in such blood was not made out; but it certainly was not volatile. Though we have found no diminution of the salts in the blood of Cholera patients, yet, of necessity, the

total amount in the system must be decidedly lessened, but so also is the total bulk of the blood.

Urea. It was stated in our first part, that urea had been detected in the blood and other fluids in Cholera; but in most cases its amount was not estimated, and no relation between the quantity of this principle and the stage or intensity of the disease observed: to this point we paid some attention, and I think that the results obtained will prove interesting. In Cases II and III (Tooting children), no urea was found, and certainly it did not exist in the blood to any large extent. Still, from the small amount of blood examined, a quantity greater than in health might have escaped discovery; and that such was the case, we have some evidence in the increased amount of uric acid, which, when suspension of the urinary excretion takes place, is found in excess in the blood along with the urea, and can be more easily discovered, not being so liable to suffer decomposition; still the urea was not in large excess. In these cases, death took place during the stage of collapse. In Case III it will be also observed that no urea was found, but Dr. Parkes remarks, that it may have been present in small quantities, but certainly *not in large excess*. The blood in Case IV was not examined for this principle. In Case V, urea was sought for twice; first, when the patient was in a state of partial collapse, next, in the blood obtained from the large vessels after death; and it will be seen, that in the collapse stage (not intense) 1000 parts of blood contained 0·38 part of urea; after death (partial reaction having taken place), as much as 0·92 part was found in the same quantity of blood. In Case VI, where the blood was taken after death, the patient having had partial reaction, and then becoming semi-comatose, 0.65 part of urea was obtained from the 1000 parts of blood; and, lastly, in Case VII, where reaction had been restored, and the patient was suffering considerably from head symptoms and fever, the 1000 parts of the serum of the blood taken during life, yielded 1·14 parts of urea. So we find that the urea gradually increases in amount, from the cold stage to that of febrile reaction. The explanation of this phenomenon is, I think, exceedingly simple; for I should imagine, that in intense and sudden collapse, not only is the function of the urinary excreting organ diminished or suppressed, but also the vital metamorphoses, and therefore the formation of urea, are likewise nearly suspended. This would account for the small amount usually found in the collapse, and probably the quantity varies inversely with the intensity of this state; but when partial reaction ensues, and the vital changes take place with greater activity, should the function of the kidneys not be at the same time restored, urea must accumulate in the blood, and the amount must depend on the degree of the reaction (febrile or not), and the extent of suppression of the urinary secretion. This view is certainly supported by the results which have been as yet obtained, not only recently by ourselves, but also in the former epidemic by Dr. O'Shaughnessy and others.

CONCLUSIONS.

In comparing the recent analyses with those given in the first part of the paper, it will be seen, that as far as concerns the physical properties of the blood, the diminished amount of water, and the consequent increase of the solid portion, also the high specific gravity of the

serum, and its tendency to become less alkaline, our own conclusions perfectly agree with those previously made; and therefore, that conclusions 1, 2, and 3, before given, are thus far confirmed. With regard to (4) and (5), concerning the salts and urea, our conclusions must be—

4. That, in Cholera, the saline constituents of the blood are not only not decreased in amount, but sometimes exist even in increased proportion, and that the diminution of its alkaline reaction is not due to the loss of salts, but to the impeded excretion of organic acids, which are constantly being formed in the system.

5. That urea usually exists in increased quantities in Cholera blood, but that the amount differs considerably in the different stages of the disease; being but small in quantity in the intense stage of collapse, increasing during reaction, and in excess when consecutive febrile symptoms occur.

From what we have ascertained as to the alterations which take place in the blood in Cholera, we shall have little difficulty in solving the problem proposed in the early part of our paper—"Given a specimen of blood, to determine whether it is derived from a patient suffering from Cholera." For it will be seen, from the several conclusions we have drawn, that in this disease the blood undergoes changes, not observed in any other morbid state of the system; and should a specimen of blood be found possessing the characters described under the conclusions 1, 2, and 3, (Part I), no doubt can be entertained as to its being derived from a Cholera patient; and we can determine, to a certain extent, the stage of the disease, by examining it, with regard to the points in conclusion 5, (Part II).

There are certain points, with regard to the pathology and therapeutics of the disease, which the consideration of the results of the chemical examination of the blood and other fluids naturally suggest to the mind. In the first place, it would appear that the Cholera poison, when introduced into the blood in sufficient quantities, causes an intense exosmotic action of the mucous membrane of the alimentary canal, at the same time destroying its endosmotic power. The blood therefore being deprived of a certain amount of water and salts, by the intestinal evacuations, and, not possessing the power of regaining these by absorption from the stomach, becomes altered in the manner we have seen, and ill suited for circulation in the extreme vessels; thereby giving rise to suppression of the various excreting functions, by which in turn it is rendered impure. But a question now arises, is this condition of blood essential, and cannot the stage of collapse be induced by the direct influence of the poison? There are certain cases known by the name of "Cholera Sicca", which would seem to favour this latter view; but from what I can ascertain, no analyses of blood have been made in such, and as far as my own experience goes, the amount of intestinal evacuations in any case is by no means an indication of the extent to which the blood has become altered. This is also well shown by the condition of the blood in severe bilious diarrhœa, in which its specific gravity appears to remain unaltered, the endosmotic or absorbing power probably remaining entire. Supposing this latter property entirely suspended, it would require but little amount of intestinal evacuation to cause this condition of blood; the loss of water by the skin and lungs would alone

soon produce it; and that this power is sometimes lost will be seen in examining Case 5 (Worts), in which, although many gallons of water were taken into the stomach, the blood still continued to increase in specific gravity.

Assuming that such a condition of intestinal mucous membrane exists in Cholera, it gives us but little hopes of effecting much by remedies administered by the mouth, during the collapse; and experience has shown us, that very little confidence can be placed in them. The saline drinks, recommended by Dr. Stevens, must here fail, as even water is unable to be absorbed. This led to the method of injection of saline fluids into the veins; and certainly it appears that, even in the most intense stage of collapse, patients may, for a time, be restored by their employment. Unfortunately, however, the improvement has, in most cases, proved but temporary; but still enough has been seen, to cause many to think that their use is strongly called for. Should they be ever again employed, I think that more attention should be paid, both to the nature and quantity of the salts contained in the fluid, than has hitherto been done; and a solution should be employed whose composition resembles, as much as possible, the portion of the blood which has been lost. One would be apt to think, that the blood could not bear with impunity a considerable quantity of carbonate of soda in place of the phosphate; yet such a substitution, I believe, has generally been made. May not the use of improper fluids have been in part the cause of the truth of the remark quoted by Dr. Watson, in his Lectures on the Practice of Medicine, that, "However it might be with pigs and herrings, *salting* a patient in Cholera was not always the same thing as *curing* him."

Might not some agent be injected, which would tend to prevent the exosmotic action of the intestines? Certain bodies, possessing such a power on membranes, have been found. When reaction takes place, and the watery portion of the blood becomes restored, it would then seem rational to employ drinks containing small quantities of the salts; for it does not seem improbable, that the saline deficiency, which must then occur, unless supplied, may tend to prevent the due action of the kidneys and other excreting organs. At this time also, other remedies, as calomel, etc., should be given, with the intention of restoring the excretions.

63, Harley-street, March 31st, 1849.